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Honoring Wendell R. Garner, this conference on the Perception of Structure shows how judgments and cognitions depend on the possibilities of the situation. Topics examined include aesthetics, representation in animals and humans, attention, color, development, goodness, integrality, language, imagery, perceptual organization, process models, self-organizing systems, theory, randomness, and retrieval. *Keywords:*

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THE PERCEPTION OF STRUCTURE

Gregory R. Lockhead and James Pomerantz
Duke and Rice Universities

A conference was held at Yale University, May 22-23, 1989 to honor Professor Wendell R. Garner at the occasion of his retirement. The meeting, which was supported by AFOSR, APA, Duke U., NIMH, ONR, Rice U., and Yale U., was attended by invited graduate students, post-doctoral fellows, moderators, discussants, and members of the community at New Haven. The program and abstracts of the invited addresses are given in this report. The complete texts of the addresses will be published as a book by the APA.

Program:

Monday Morning, May 22, 1989

- Perception** Moderated by Ray Hyman, U. Oregon
- 8:30 - Coffee/Rolls/Greetings
8:45 - 9:00 Welcome: Greg Lockhead/Jim Pomerantz
Welcome to Yale: Robert Crowder
9:00 - 9:20 James Cutting, Cornell U.
Why our stimuli look as they do.
9:25 - 9:45 Stephen Palmer, U. of California, Berkeley
Goodness, Gestals, Groups, and Garner: Symmetry subgroups
as a theory of figural goodness.
9:50 - 10:10 **Break**
10:10 - 10:30 Roger Shepard, Stanford U.
Integrality Versus Separability of Stimulus Dimensions:
Evolution of the Distinction and a Proposed Theoretical
Basis.
10:35 - 10:45 Warren Torgerson, The Johns Hopkins U.
Commentary: Construction of Perception
10:50 - General Discussion
12:00 - 1:30 Lunch



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Monday Afternoon

- Stimulus Attributes** Moderated by John Flowers, U. Nebraska
1:30 - 1:50 Irving Biederman, U. Minnesota
Pattern Goodness and Pattern Recognition.
1:55 - 2:15 Howard Egeth, The Johns Hopkins U.
Redundancy Gain Revisited: Evidence for parallel processing
of feature conjunctions.
2:20 - 2:40 Robert Crowder, Yale U.
Imagery for Musical Timbre.
2:45 - 2:55 Susan Chipman, ONR
Commentary
3:00 - General Discussion
- Language** Moderated by Anthony Cecala, Texas Instruments
3:30 - 3:50 Herbert Clark, Stanford U.
Words, the World, and their Possibilities
3:55 - 4:15 James Neely, SUNY Albany
On the Influence of Response Uncertainty and Task Structure
in Retrieval from Lexical Memory.
4:20 - 4:40 George Miller, Princeton U.
Lexical Echoes of Perceptual Structure

4:45 - 4:55 Sam Glucksberg, Princeton U.
Commentary
5:00 - General Discussion
6:30 - 7:30 Open Bar and Conversation
7:30 - Banquet

Tuesday Morning, May 23, 1989

Animal Behavior Moderated by Larry Marks, Pierce Foundation
9:00 - 9:20 Donald Blough, Brown U.
Perceptual Analysis in Pigeon Visual Search
9:25 - 9:45 Donald Riley, U. California at Berkeley
Represenation of Multidimensional Stimuli in Pigeons (with Michael F. Brown)
9:50 - 10:00 Anthony Wright, U.Texas Sensory Sciences Ctr.
Commentary
10:05 - 10:40 General Discussion
Randomness Moderated by Emanuel Leeuwenberg, U. Nimjegen
10:40 - 11:00 Michael Kubovy, U. Virginia
Elements of Generative Randish (with David Gilden)
11:05 - 11:25 Gregory Lockhead, Duke U.
Subjective Randomness, Aesthetics, and Structure (with Sarah Hollingsworth Lisanby)
11:30 - 11:40 Daniel Kahneman, U. California Berkeley
Commentary
11:45 - 12:00 General Discussion
12:00 - 1:30 Lunch

Tuesday Afternoon

Attention Moderated by Robert Melara, Pierce Foundation
1:30 - 1:50 Donald Broadbent, Oxford U.
Early Selection, Late Selection, and the Partitioning of Structure
1:55 - 2:15 Charles Eriksen, U. Illinois
Response Competition produces a "fast same effect" in same-different judgments (with James St. James)
2:20 - 2:40 James Pomerantz, Rice U.
The structure of visual configurations: stimulus vs. subject contributions.
2:45 - 2:55 Anne Triesman, U. California Berkeley
Commentary
3:00 - 3:30 General Discussion
Perceptual Organization Moderated by Soledad Ballesteros, UNID
3:30 - 3:50 Brian Shepp, Brown U.
Perception of Color: A comparison of alternative structural organizations.
3:55 - 4:15 Linda Smith, U. Indiana
Dimensions as Self-organizing Systems
4:20 - 4:40 John Morton, MRC London
The role of meaning in infant face perception (with Mark Johnson)
4:45 - 4:55 Deborah Kemler-Nelson, Swarthmore College
Commentary
5:00 - 5:10 General Discussion
Final Commentary and Thank You Moderated by Pomerantz and Lockhead
5:15 - Wendell Garner, Yale U.

Abstracts:

Irving Biederman, U. Minnesota
Pattern Goodness and Pattern Recognition

Measures of pattern goodness may essentially be irrelevant to the representation of objects. Instead effects attributable to pragnanz may reflect the workings of a general system of three dimensional object recognition in which complex images are segmented into parts whose representations are viewpoint invariant and robust to noise.

Donald Blough, Brown U.
Perceptual Analysis in Pigeon Visual Search

Four lines of research are summarized in which data from visual search tasks are brought to bear on the question of perceptual analysis in pigeons. Birds received food for pecking at small black target forms that appeared among distractors on a white computer screen. The primary independent variable was the speed with which the target was found. (1) Search speed and accuracy were used to scale similarity among letters of the alphabet. Clusters of similar letters shared putative features, such as loops or open centers; these data corresponded well to results from humans. (2) Search RTs based on forms differing in one dimension were largely independent of the level of an irrelevant dimension, suggesting separability or analytic perception. (3) Search asymmetries indicated that different aspects of simple forms may function as features in pigeons than in human subjects. (4) Covariation of search RTs across trial blocks suggested that pigeons shift their attention among features and that functional features can be identified by these shifts. Taken together, the studies illustrate a comparative approach to perceptual problems that heretofore have been studied primarily in humans.

Donald Broadbent, Oxford U.
Early Selection, Late Selection, and the Partitioning of Structure

A small set of features may create a larger array of possible events, each identified by the particular combination of features it possesses; and a sub-set of this array can then be selected in a number of different ways. In a known set of words, for example, all those possessing a particular letter, or heard coming from one spatial location, may be selected. Alternatively the sub-set may be chosen only on combinations of the underlying features, as when letters are selected from amongst irrelevant digits. Garner analysed the structure of such selections, and the way they partitioned the same total 'constraint' in different ways. In this paper a parallel is drawn between Garner's analysis and the experimental paradigms used in studying attention. The results of a number of such experiments are reviewed, and demonstrate that the structure is important in predicting human performance. Thus the attentional mechanisms adapt to the form of constraint, and Garner's original analysis is re-affirmed.

Herbert Clark, Stanford U.
Words, the World, and their Possibilities

By the principle of possibilities, we understand what an entity is with reference to what it could have been. The word red, for example, belongs to both a domain of lexical possibilities (all English words) and a domain of conceptual possibilities (all conceivable denotations). But on any occasion the word is intended to be understood against much narrower domains. Speakers and addressees restrict the domains on the basis of their momentary common ground--that information they believe they share and is readily accessible at the moment. For an utterance of

red potato, the two domains might be the primary color words and the possible colors of potatoes. The color denoted by red, therefore, changes with the occasion of use; compare red cabbages and red hair, or a red face from sunburn, embarrassment, or clown makeup. Word meanings, it is argued, are not static dictionary entries, but products of a lexical process.

Robert Crowder, Yale U.
Imagery for Musical Timbre

A pitch-discrimination method for the study of auditory imagery is described: Following the demonstration that people make same-pitch judgments more readily if two successive tones have the same timbre than if not, it is shown that this matching effect occurs even when the first of the tones is imagined rather than actually heard. Synthesized tones were introduced in several new experiments to discover whether the capacity for forming mental images of timbre cues was based on their spectral properties or their dynamic (onset) properties. Results were clear in showing the former but not the latter. Large individual differences in the capacity to separate the qualities of pitch and timbre were discussed.

James Cutting, Cornell U.
Why our Stimuli Look as They do

Perception is sometimes thought to be an inferential process, and sometimes thought not to be. In fact, however, inferences are broad enough to encompass all theories of perception. I explore this breadth in three kinds of perceptual inference--one inductive and two deductive. The inductive view, consistent with Garner's ideas of critical realism, demands a role for cognition in perception because information underspecifies what is perceived. This view may at times be true, but I claim only because researchers use reduced, or relatively impoverished, stimuli. The first deductive view, consistent with Garner's and Gibson's ideas on direct realism, claims information in natural environments specifies (is exactly matched to) percepts. Researchers of this persuasion appeal to enriched stimuli, but typically sacrifice in their search for information. A second deductive view, which is my own, claims potentially useful information overspecifies what is to be perceived. The perceiver selects or combines sources of available information according to needs and contexts.

Howard Egeth, The John Hopkins U.
Redundancy Gain Revisited: Evidence for parallel processing of feature conjunctions.

According to feature-integration theory (e.g., Treisman & Gelade, 1980), when subjects search for a target defined in terms of a conjunction of several separable dimensions, such that each nontarget shares a feature with the target, then each display element must be examined in turn until the target is found. The usual method for assessing whether search is serial and self-terminating is to measure reaction time as a function of display numerosity. However, serious problems with this methodology have been pointed out (e.g., Townsend, 1972). In the present experiments subjects indicated whether a specific target element was present; on some trials two targets were presented. Analysis of the reaction-time distributions using a method introduced by Miller (1982) indicated that the decrease in reaction time found on dual-target trials was too great to be compatible with any sort of serial-decisions model (as well as certain varieties of parallel models). We conclude that at least two objects may simultaneously have their color and form conjoined into unified percepts.

James St. James and Charles Eriksen, U. Illinois

Response Competition Produces a "Fast Same Effect" in Same-different Judgments.

Eriksen, O'Hara and Eriksen (1982) have proposed that one basis of the "fast same" effect obtained on comparison tasks arises from response competition. Feature or dimensional similarities or overlap between the comparison targets prime a "same" judgment which tends to inhibit the execution of the response signifying "different." Garner (1988) has recently extended this competition process to account for the inconsistency of results that are obtained for integral and separable dimensions between classification tasks and comparison tasks. In the present experiment we used a recently developed direct measure of response competition (abortive responses) (St. James, 1989) to assess the degree of response competition that occurred on same and different trials. Subjects judged letter pairs on a criterion of physical identity. In addition to "same" pairs, there were "slightly different" pairs and "very different" pairs. In accordance with the prediction of the Eriksen et al (1982) model, the incidence of abortive double responses was appreciably and significantly greater for "slightly different" pairs. Pairs that were the same or "very different" did not differ significantly on either RT or the direct measure of response competition.

Wendell Garner, Yale U.

Final Commentary and Thank You

This is a final commentary and thank you. My commentary part is going to be a light review of some of the topics I have researched, but with a very special emphasis on methodological issues and problems that I have encountered along the way, and that I think have a great deal to do with our understanding or failure of understanding of the perception of structure.

Michael Kubovy and David Gilden, U. Virginia

Elements of Generative Randish

One hundred twenty four subjects were asked to simulate a series of 240 tosses of a fair coin. Multiple regression analyses revealed that sequence generation is constrained by run length, the frequency of alternation, and the imbalance between heads and tails. Subjects did not avoid patterned or symmetric subsequences. These results are discussed in terms of the way subjects view the history of prior responses as they form future responses.

Sarah Lisanby and Gregory Lockhead, Duke U.

Subjective Randomness, Aesthetics, and Structure

Subjective randomness is related to what people expect to encounter. It is different from stochastic randomness. To examine what determines whether an event will be judged as random or as not random, we asked people to generate strings of random digits, to judge if digit strings were random, to place random or not random dots within geometric figures, and to place dots in aesthetically pleasing locations. The results show that subjectively random events are structured. Compared to chance expectations, when numeral strings appear random, then successive numbers repeat too infrequently but otherwise are overly similar, and non-successive numerals are too different from one another. Also, human-generated numerals appear more random than do stochastically independent numerals. When dots within a square or rectangle or diamond appear to be randomly located, then they tend to be in a figural balance with features of the stimulus. This structure is highly similar to that of aesthetically pleasing locations. It is suggested in an aside that some art forms that have been considered to be random may, instead, be structured according to the same principles involved in subjective randomness. It is concluded

that when people attempt to produce a random event they do so by beginning with an aesthetically pleasing response which they then modify slightly so it appears random, and when people judge whether an event is random they compare it to an aesthetically pleasing event.

George Miller, Princeton U.
Lexical Echoes of Perceptual Structure

Many concepts found in scientific theories of perception originated in common sense and were later refined or redefined for more precise use. One place to begin an exploration of these ideas is with words that are used to refer to concrete objects, since object identification presupposes features that everyone can recognize or discriminate. The folk psychology of perception, as seen from the perspective of lexical analysis, presupposes three major kinds of distinguishing features: attributes, parts, and functions. Attributes were the first features to be extracted from common sense and studied extensively; Gestalt psychologists opened the systematic study of parts and their relations to one another; the perception of function, however, has been relatively neglected, although affordance theory recognizes its importance. Most scientific theories of perception have much to say about attributes and parts, but the recognition of function is only beginning to receive the attention it deserves.

John Morton and Mark Johnson, MRC London
The Role of Meaning in Infant Face Perception

It has been claimed recently that the reaction of newborn infants to face-like stimuli is mediated by energy. We examine and reject this proposal and describe an alternative view whereby it is the structure of the face which attracts the infant's gaze through the operation of a template-like device which we call CONSPEC. We show in addition that the infant is still learning the structural description of the face between 3 and 5 months, at which time dynamics is integrated into face perception.

James Neely, SUNY Albany
On the Influence of Response Uncertainty and Task Structure in Retrieval from Lexical Memory

Garner's research has provided three general principles of task analysis: (1) The theoretical inferences one draws from data must take into account the stimulus-to-response mappings required by the task in which those data were collected. (2) The "meaning" that a subject extracts from a particular stimulus on a particular trial depends on the nature of other stimuli that appear on other trials in the experiment. (3) Subjects are clever and will use whatever information is available to them for optimizing their performance. An application of these three principles to lexical decision and pronunciation tasks yields an explanation of the dissociative semantic priming effects that occur in these two tasks and at the same time causes us to challenge conventional wisdom that word-frequency effects in these two tasks are localized only in lexical access. The successful application of these three general principles to domains as diverse as word identification and the perception of the dimensional structure of "simple" geometric patterns encourages their continued use.

Steven Palmer, U. California Berkeley
Goodness, Gestalts, Groups, and Garner: Symmetry subgroups as a theory of figural goodness

A theory of the Gestalt notion of "goodness" is described based on the mathematical construct of symmetry subgroups. Its close relation to Garner's theory of rotation and reflection

(R & R) subsets is described, and goodness rating data for spatial patterns are reported that favor the symmetry subgroup formulation. The theory is then extended to cover the judged goodness of events in space-time. It is argued that the perceptual structure of space-time includes only reflectional symmetries about the spatial and temporal axes, and preliminary data supporting this conjecture are presented. Finally, the theory is elaborated to include local symmetries as well as global ones. This augmented theory is formalized and tested against data on the rated goodness of the relation between a probe dot and a surrounding figure.

James Pomerantz, Rice U.

The Structure of Visual Configurations: Stimulus vs. subject contributions

Visual configurations present the perceiver with a wealth of features that could be attended. Garner's research provides converging operations that help identify which of this myriad of features the perceiver actually attends. This chapter explores some results of experiments inspired by Garner's work, with a particular emphasis on one specific question: To what extent are the attended features dictated by the stimulus itself rather than chosen strategically by the perceiver? In other words, is the structure in visual configurations essentially a stimulus concept or an organismic concept? Results from previously reported speeded classification tasks show many instances where perceivers apparently fail in tasks designed to require selective attention to specified features, suggesting that subjects may be incapable of accessing these features individually. However, experiments reviewed here provide many instances where subjects are free to choose the features to which they will attend, suggesting that previous results should not be interpreted as showing failures of selective attention. In certain cases, for example, simply instructing subjects to attend to specific features leads to compliance. To be sure, the stimulus limits the ensemble of possible features, and early perceptual processes may bind or glue certain physical features together thus preventing them from being attended selectively. But within these constraints, perceivers may have more latitude than has previously been demonstrated. At this time, we need additional converging operations to help us discriminate between situations where perceivers cannot attend to specific features and situations where they simply chose not to attend.

Donald Riley and Michael Brown, U. California Berkeley

Representation of Multidimensional Stimuli in Pigeons

Most researchers of animal learning have assumed that elements of stimulus compounds are processed independently and summed linearly. Research with pigeons in Element and Compound matching-to-sample tasks suggests that this assumption generally provides a good description of the data. Two exceptions are, however, of interest. (1) Precuing of one element of a compound is more efficient when the elements (i.e., a color and a line orientation) are separated than when unified (as in a colored line). (2) While prior experience with elements only results in transfer to compounds, the reverse is not true. Pigeons trained to process compounds with no experience with elements show no transfer to Element matching-to-sample. The results suggest that independent processing of elements of a compound results from a history of processing the elements outside of the compound.

Roger Shepard, Stanford U.

Integrality Versus Separability of Stimulus Dimensions: Evolution of the distinction and a proposed theoretical basis

Noting the importance that W.R. Garner has long attached to the concepts of integrality and separability of stimulus dimensions and to the use of converging operations for establishing

such psychological concepts, this chapter first reviews two types of converging evidence that originally pointed toward the integral-separable distinction: (a) evidence that stimulus similarities implicate the Euclidean metric for stimuli that differ along psychologically integral dimensions (such as lightness and saturation of colors) and something closer to the city-block metric for stimuli that differ along psychologically separable dimensions (such as size and orientation of shapes); and (b) evidence that classification learning and performance are determined more by overall similarities for stimuli differing along integral dimensions and by dimensional structure for stimuli differing along separable dimensions. Drawing on a recently proposed theory of generalization, the integral or separable character of the relation between dimensions is then considered as a possible accommodation to the correlational structure of natural kinds the world in which we have evolved.

Brian Shepp, Brown U.

Perception of Color: A comparison of alternative structural organizations

The perception of color may be characterized according to either of two form of organization: color categories or the subjective dimensions of hue, saturation, and brightness. The experiments reported test the hypothesis that categorical relations are primary, and constrain the perception by dimensions, which is secondary. Subjects were given restricted classification tasks in which the classifications could be based on holistic or dimensional relations. They were instructed to classify by dimension and to name the dimension that provided the dimensional relation. Subjects failed to identify hue when members of the triad were chosen from the same category, but were successful when the triads provided a between category comparison. The classifications by either saturation or brightness identities were modestly successful either within or between color categories. Naming responses, however, indicated that brightness identities were often confused with saturation identities and vice versa. Taken together, the results indicate that color categories are organized holistically, and provide constraints on the analysis by dimensions.

Linda Smith, U. Indiana

Dimensions as Self-organizing Systems

Garner argued that we do not perceive individual stimuli but instead perceive structured sets of stimuli. Individual stimuli are understood in context by their relation to alternative stimuli. Moreover, according to Garner, the relations that structure perception are given in the world. Structure is in the stimulus and exists independently of the perceiver. This chapter considers evidence of developmental changes in perceived structure and argues for a view in which structure is not in the stimulus but is created and emergent in interacting psychological processes. Evidence on developmental changes in the polar structure of dimensions is presented. The evidence indicates that between the ages of two and five years a cross-dimension relation between big and loud emerges and a cross- dimension relation between big and dark dissolves. It is argued that these developmental changes stem from multiple interacting processes that include perception and language. The results indicate that basic perceptual relations can change radically with development. They also show that structure is not a stimulus concept but is a psychological one. A metaphor for thinking about perceptual structure as a stable and emergent process is offered.